A comparison of transplant methods for eelgrass (*Zostera marina* L.) restoration in Frenchman Bay

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We have been working with community volunteers to restore eelgrass in upper Frenchman Bay since 2007. We have experienced success with a variety of methods, which include transplanting eelgrass on wire or biodegradable grids as well as stapling eelgrass directly into sediment in subtidal areas of the bay. We have determined that biodegradable grids optimize the ultimate success of transplanted eelgrass and work best for engaging community volunteers.

Eelgrass is a very important component of the near-shore marine environment, with a host of functions from stabilizing the sediment to providing shelter and food for a variety of marine organisms including developing fishes[1]. While in 1996 there was 80% coverage of subtidal areas of upper Frenchman Bay, by 2007 the coverage had dropped to 0.5%. It is not surprising that the Frenchman Bay finfish landings crashed at about the same time. Overfishing certainly contributed to this demise, but lack of sufficient nursery grounds may have accelerated the decline, and fisheries may not recover without restoration of eelgrass habitat. Since 2007, we have been testing eelgrass restoration methods in upper Frenchman Bay.

Figure 1. Wire and biodegradable grids. Volunteers are tying plants onto both types.

Eelgrass (*Zostera marina* L.) reproduces both by vegetative reproduction and by seeds and can be successfully restored by transplantation of vegetative shoots or by seeding. We have had most success with transplantation methods with the help of community volunteers. Eelgrass plants were tied to weighted wire grids[2] and placed on the ocean bottom in suitable locations. These transplants established roots over the winter, and the grids were removed in the spring. Unfortunately the removal of wire grids resulted in an average loss of 60% of the transplants. Therefore, we sought an improved method for transplanting eelgrass. We compared wire grids with a "horizontal rhizome" method that involved stapling plants into the sediment using bent bamboo stakes[3]. We also compared wire grids with a new biodegradable grid (BDG) that did not require removal after transplant (Fig 1).

Figure 2. A bamboo "staple" with two plants.

Wire grids (2 x 2 ft) were cut from plastic-coated 1.5 x 1.5 inch wire mesh sold for making lobster traps, and were weighted with two construction bricks secured to the grids with bailing wire. The BDGs were constructed of a 2 x 2 ft wood frame, with corners secured by a mortise and tenon joint. With the help of many community volunteers, we constructed BDGs by assembling frames, stringing them with sisal twine, and tying sand bag weights to each corner. Sisal twine was strung through notches in the wood rails, and the grid was weighted with 4 cotton bags filled with sand (~1.5 lb. each). Plants were tied to each wire grid and BDG using biodegradable floral tape. The bamboo “staples” were made from 18” skewers, soaked and bent to form a “V” shape (Fig 2). Plants were stapled into a 2 x 2 ft area, to equal the density of plants on the wire grids. We compared the staples with the wire grid method at Hadley Point, and compared BDGs to the wire grid method at a variety of locations in upper Frenchman Bay. Figure 3 shows the design of these experiments.

Community volunteers were recruited in a number of different ways. We encouraged student and teacher participants in our eelgrass education programs to join us in grid-making and restoration efforts. We encouraged them to invite family and community members to get involved. We also sent announcements to all staff members and summer visitors at MDIBL. In all, 93 volunteers ranging in age from 12 to 65 contributed 556 hours to these restoration experiments.

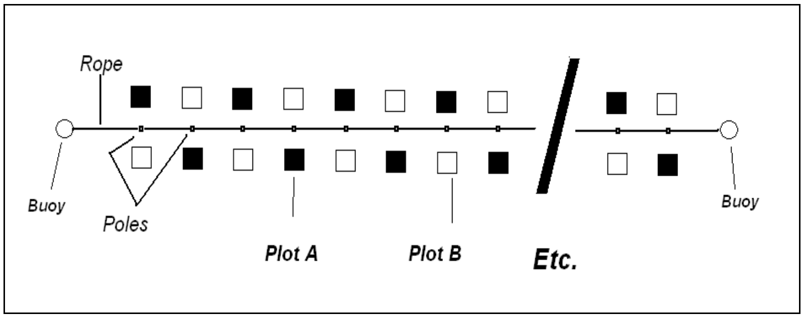

Figure 3. Pattern of deployment for each experiment. The buoy anchors were connected by rope, with PVC poles driven into the substrate at 5 ft intervals along the rope. Wire grids (Plot A) and stapled plants or BDGs (Plot B) were placed with their near edges 2.5 ft on each side of the poles, resulting in grids spaced 5 ft in each direction.

On 07/12/2009, volunteers tied 24 plants to each of 20 wire grids at Hadley Point in Frenchman Bay. These grids were transported to the restoration site with 480 additional plants and 240 staples. Wire grids with plants were set down on the ocean bottom. In between the wire grids, 24 plants were stapled into the sediment by student interns, using a 2 ft x 2 ft PVC pipe frame as a guide. Most community volunteers could not participate in the stapling, due to the challenges of working in cold water with a mask and snorkel. On 09/09/2009 (43 days later), plants on each wire grid and in each stapled patch were counted. On 03/31/2010 the wire grids were removed. On 05/12/2010, the plants were re-counted; the bamboo staples had degraded and could not be found. Transplants did equally well when transplanted on grids or stapled into the sediment, until after grids were removed, when the disadvantages of wire grids became apparent (Fig 4).

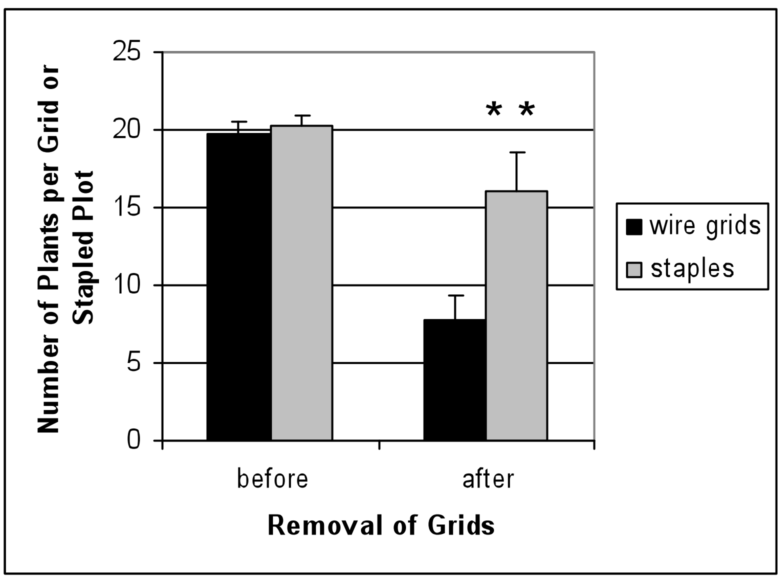

Figure 4. Transplants on wire grids did equally well as those stapled into the sediment until after wire grid removal. After grid removal, there were significantly more plants in the stapled plots than where the wire grids had been (t-test, P = 0.006). N = 20 grids and N = 20 stapled plots.

On 06/20/2011, we worked with community volunteers to tie eelgrass to 20 wire and 20 BDGs (20 plants each) and transfer them to Berry Cove and Hadley Point. On 05/09/2012 we counted the number of plants per grid in Berry Cove, and on 07/06/2012 counted the Hadley Point site. We repeated this experiment (10 grids of each type) at two adjacent sites at Thomas Island, which were planted on 07/20/2011 (S) and 08/12/2011 (N); both sites were counted on 5/9/2012. Results of these experiments are summarized in Figure 5. At Berry Cove, there was a significant difference between the numbers of plants on biodegradable grids as compared to wire grids (t-test, P = 0.035). The Hadley Point and the two Thomas Island experiments also resulted in fewer plants on wire than on biodegradable grids, but at neither of these latter sites was the number of plants on wire grids and BDGs significantly different. When data from all 60 grids of each type were combined, the wire grids were much less successful than the BDGs, even before plant removal (t-test, P = 0.004).

The increased number of plants on the BDGs compared to wire grids (before removal) was unexpected. One possible explanation is that the flexibility of the twine on the BDGs allowed better contact with the uneven substrate than the rigid wire grid structure. Perhaps something in the wood or twine of the BDGs nourished the plants, or something in the wire grids inhibited their growth. At all sites, BDGs were never less effective than wire grids.

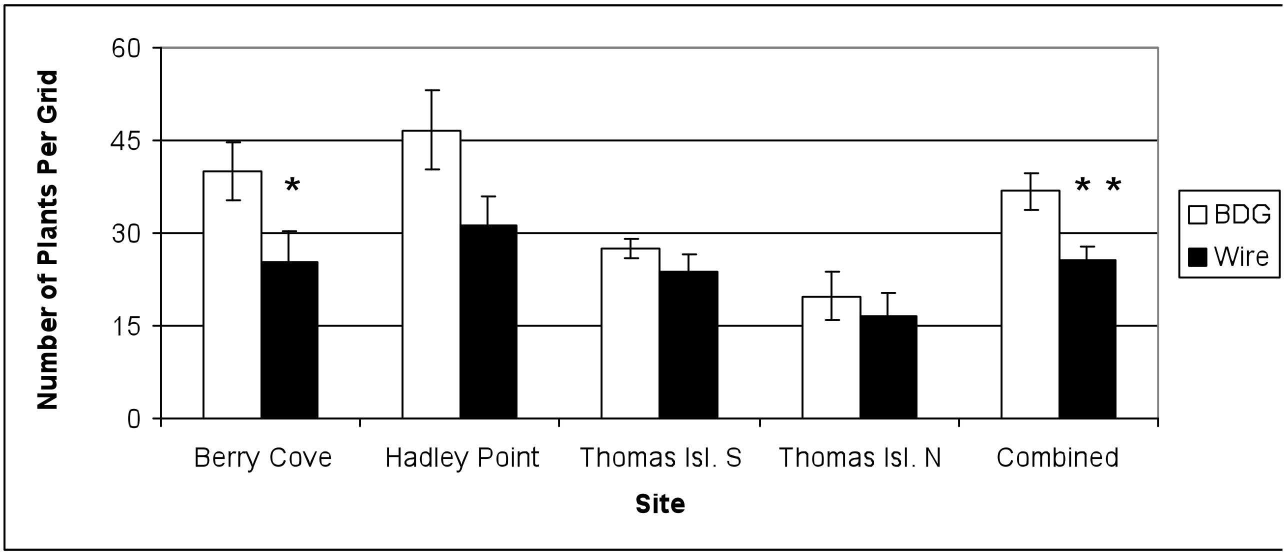

Figure 5. Transplants on BDGs did equally well or better than those on wire grids, prior to grid removal. At Berry Cove, there were significantly more transplants on BDGs than on wire grids 11 months after transplant (t-test, $P = 0.035$). $N = 20$ grids of each type in each location with the exception of Thomas Island, where $N = 10$ grids of each type in each area, south (S) and north (N). When grids from all locations were combined ($N = 60$ of each type), the difference between BDGs and wire grids was highly significant (t-test, $P = 0.004$).

In our experience, both staples and BDGs are effective in transplanting eelgrass and result in successful establishment of plants after one year. Although wire grids work for initial transplantation of eelgrass, the subsequent removal of grids causes significant disruption of transplants. The staples method is laborious and does not provide opportunities for community volunteers to be engaged in restoration projects whereas the BDG method provides opportunities for involvement of community volunteers both in construction of grids and tying plants onto grids prior to transplant. Including community members in eelgrass restoration serves to raise awareness about the importance of coastal habitats to the overall health of the bay and the marine livelihoods that depend on it. Therefore, restoring eelgrass using BDGs in a community-based approach is our method of choice for future transplanting efforts.

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